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RADAR Littoral Studies Workshop

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Abstract

Don Atwood, Alaska Satellite Facility, University of Alaska Fairbanks
Monitoring Marine Ecosystems with Synthetic Aperture Radar

Darkness and cloud cover limit opportunities for using spaceborne optical sensors to monitor the marine environment. An alternative exists in the day-night, all-weather capabilities of synthetic aperture radar (SAR). The transmitted microwaves of SAR interact with the roughness of the sea surface. Since surface roughness is modulated by both atmospheric and oceanographic phenomena, SAR provides a unique means to observe sea ice, surface winds, frontal systems, upwelling, internal waves, currents, eddies, oil spills, storm water discharge, and coastal bathymetry.

As the U.S. Order Desk for RADARSAT-1, the Alaska Satellite Facility (ASF) has provided operational support to NOAA/NESDIS, the National Ice Center (NIC), and the Canadian Ice Service (CIS) for the past fifteen years. Upon downlink at ASF, RADARSAT-1 data is processed to near-real-time image products and processed for wind products, sea ice analysis, and ship detection. Successful interaction with these agencies has demonstrated that SAR can be effectively used to yield important near-real-time information for decision makers. Timely data has been utilized by U.S. Coast Guard in responding to oil spills, walrus researchers requiring operational support for field campaigns, ice breakers requiring navigational guidance, and the National Weather Service for wind speed validation.

Through the availability of higher level products, GIS compatible formats, and the development of new applications, SAR is beginning to be embraced by new communities of users. The intent of this presentation is to address the many marine applications of SAR and to discuss current and planned developments of ASF near-real-time products for the Gulf of Alaska, the Bering Sea, and the Arctic coastline.

David Hulslander, ITT Visual Information Solutions
SARscape Technical Briefing: A Complete SAR Analysis Solution

SAR is an objective approach to analyzing an area of interest and is a powerful tool in agricultural, military, environmental, disaster management, insurance, and urban planning applications. It can be used to track growth of vegetation, estimate crop yields, identify objects, monitor oil spills, assess damage, and more. The SARscape Module for ENVI offers a unique, all-in-one solution for the SAR data analysis workflow, from data ingest to final product output. Used alone or in conjunction with other remotely-sensed data, SAR data provide a unique layer of information - exposing new details to help you make the most informed decisions possible.

Core SARscape functionality includes processing tools for focusing, multilooking, despeckling, geometric and radiometric calibration, mosaicking, and classifying. Advanced SARscape functionality includes differential and polarimetric interferomentry tools, and tools for generating DEMs and surface models, land displacement maps, coherence maps, and change maps. SARscape supports all of the major current sensors and follows a rapid-development scheme, allowing for rapid support of new sensors as well. Because SARscape is fully integrated with ENVI, it also allows you to combine your SAR data with all other sources of remotely sensed data. This integration also means the full power of ENVI's remote sensing tools and IDL's advanced analysis capabilities can be brought to bear on even the most complex remote sensing problems.

Ken Loving, General Atomics Aeronautical Systems Inc.
Lynx SAR/GMTI Radar System

Becky Morton, Bill Sharp, Fugro Earthdata

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GeoSAR - Configuration, Capabilities, Limitations, and Examples

GeoSAR is the result of a 7-year joint development effort sponsored by the National Geospatial-Intelligence Agency (NGA) between NASA's Jet Propulsion Laboratory (JPL) and EarthData. JPL designed the system and EarthData integrated it into the aircraft and developed a highly automated production center for processing the data. We will present some of the technical innovations of this dual-frequency second-generation interferometric synthetic aperture radar (IFSAR) mapping system.

Coastal areas are affected by the adjoining land, with influencing drainage and infrastructure features sometimes obscured by clouds or vegetation. GeoSAR images are an excellent substitute for traditional aerial photography for mapping features and deriving elevation data for areas with clouds and obscuring vegetation at scales ranging from 1:20,000 to 1:50,000. The GeoSAR system collects large areas of data in a single mission, night or day, and through cloud cover. For large or distant areas, these are significant advantages compared to traditional aerial photography. GeoSAR images have a resolution and level of detail equivalent to an aerial black-and-white photograph. The planimetric accuracy of the orthorectified X-band images is 2.5 m RMSE.

GeoSAR simultaneously collects both X-band and P-band data in dual baseline mode– single antenna transmit and ping-pong. In single antenna transmit mode, the radar transmits a signal from one of the interferometric antennas and receives the echo in two. In ping-pong mode, both antennas transmit and receive the radar echo through the same antenna. EarthData can vary the nature of the data processing depending on the type of terrain the GeoSAR system has imaged. The ping-pong mode effectively doubles the antenna baseline separation, thereby improving the vertical accuracy of the data.

Vertical accuracy of GeoSAR DEMs can vary from 1 m RMSE in flat terrain to 5 m (RMSE) in steep, mountainous terrain. The GeoSAR airborne system flys at ~12km MSL at ~400knts and acquires data at 370MBS. Each data take, GeoSAR collects 12 to 14 km-wide swaths of data in each frequency band from each side of the aircraft. It is capable of collecting data from 40,000 ft at an airspeed speed of over 400kts yielding a net collection rate of over 280 sq km per minute. GeoSAR operates at two frequencies simultaneously, X-band, with a center frequency of 9700MHz, and P-Band, with a center frequency of 350MHZ. The system is designed to produce high accuracy digital elevation models (DEM) through the process of radar interferometry, as well as SAR orthoimage mosaics. GeoSAR redundantly collects data from multiple elevation angles to counter terrain induced features such as "shadow, layover, and phase unwrapability." The advantage of the acquisition redundancy is realized during the mosaicking process when null pixels in one swath are filled with actual data from an overlapping swath. As a result, the incidence of gaps in the data is reduced significantly.

GeoSAR's wide bandwidth (160 MHz) guarantees excellent MAG and DEM resolution, which supports a posted image resolution of up to 1.25 m, hence providing excellent clarity in the orthorectified radar imagery.

GeoSAR X-band and P-band data is coregistered, which creates additional geographic information extraction potential. The GeoSAR system collects single-pass interferometric data in both X-band and P-band. The P-band data has proven to be an excellent source for identifying roads, hidden power lines, obscured fence lines, for mapping slopes and drainage features, and for analyzing other terrain obscured by clouds and foliage. Because of its sensitivity to water, the P-band data provides information on soil moisture or on subsurface features in arid soils.

John Ryan, Monterey Bay Aquarium Research Institute
SAR in Multidisciplinary Studies of Monterey Bay

One of the most common oceanographic structures we have seen in SAR imagery of the Monterey Bay region during summer-fall is a sharp, narrow, dark band oriented NW-SE between Santa Cruz and Moss Landing. Based on satellite SST imagery, we find that these SAR signatures are linked to water mass boundaries. Initial analysis of CODAR data for one of these bands has shown that it was in a convergence zone, consistent with formation of a surface slick. We are interested in the nature of the fronts that develop in this region, how these fronts influence the exchanges of the northern bay upwelling shadow with the adjacent sea, and how this impacts biology in the bay. For this purpose, SAR may provide a unique and valuable description of the fronts.

Gordon Staples, MDA
Ocean Intelligence and the Role of Saceborne SAR Data in the Littoral Zone

Synthetic Aperture Radar (SAR) data can be used to provide critical information in the littoral zone. A key strength of SAR is the all-weather, day-night imaging capability. In addition, SAR provides imagery world-wide that can be downlinked to a ground station, and information extracted from the SAR data can be delivered within hours to meet operational requirements. The role of spaceborne SAR data for these activities is presented in two parts.

The first part will provide an overview of the RADARSAT-2 SAR and discuss the space segment and the ground segment. The space segment will outline the RADARSAT-2 imaging modes and highlight the high resolution and polarimetry modes. In addition, the development of new RADARSAT-2 imaging modes will be discussed. The ground segment will discuss how the RADARSAT-2 system has been optimized for rapid satellite tasking, fast data processing, and near-real time data delivery.

The second part will focus on the use of SAR to provide surveillance of the littoral zone for both military and civilian applications. Military applications include the role of SAR to provide information for antisubmarine warfare (ASW). Of interest is the information from SAR to support ASW operations including ship detection, wind field extraction, and detection of internal waves. Civilian applications include illegal fisheries monitoring and oil pollution detection.

The presentation will conclude with a discussion of the role of spaceborne SAR in project Polar Epsilon. Polar Epsilon, a critical component of Canada's defence program for maritime security, will focus on four main areas: near-real time ship detection, Arctic land surveillance, environmental sensing, and maritime surveillance radar.

Howard Zebker, Radar Remote Sensing, Stanford University
InSAR Remote Sensing Over Decorrelating Terrains: Persistent Scattering Methods

Interferometric synthetic aperture radar, or InSAR, is a visual geodetic technique permitting detailed mapping of motion over wide areas. InSAR methods can measure very slow deformation rates, as low as 1 cm/yr, making the techniques extraordinarily sensitive. However, InSAR has been limited to regions without much vegetation, which shields the ground from the radar signals and contributes random motions to the observed deformation. The resulting "decorrelation" of the echoes precludes accurate displacement measurements in these areas. Decorrelation also occurs in interferograms with acquisitions separated too far in the sky. Yet certain points, denoted persistent scatterers, in a radar image are stable, do not decorrelate, and form a network of fiducial points that allow measurements in otherwise poor-quality interferograms. We have generalized an algorithm to find networks of stable points in natural terrain, rather than in urban areas, and applied the method to spaceborne satellite data. Using modern information theory to optimize persistent scatterer detection, we can now find many, many more such points than previously possible. We have applied this improved algorithm to the San Francisco Bay segments of the San Andreas and Hayward faults, and in both cases find that a large number of stable points are seen in the vegetated areas that have to date resisted InSAR analysis. Our method of integrating information theoretic estimation and detection theory to all parts of the method improves the identification, filtering, and phase unwrapping of the observations. Identification of stable true-ground scattering points permits mapping of subtle surface motions and deformations and also of "bare-Earth" topography.